Naval Aerospace Medical Research Laboratory

NAMRL SR89-2

June 1989

DEVELOPMENT OF THREE MOBILE FIELD LABORATORIES FOR THE FIELD ACQUISITION OF BIOMEDICAL PERFORMANCE DATA

and others -

by W.C. HIXSON, E.A. MOLINA, G.D. PRETTYMAN, AND J.D. GRISSETT

Naval Aerospace Medical Research Laboratory
Naval Air Station
Pensacola, Florida 32508-5700

Approved for public release; distribution unlimited.

Reviewed and approved 6/13/89

J. A. Brady

J. A. BRADY, CAPT, MSC USN
Commanding Officer

This research was sponsored by the U.S. Army Medical Research and Development Command under work unit 63764A 3M63764B995 AB.082-7.

The opinions and interpretations contained herein are those of the authors and do not necessarily represent the views, policies, or endorsement of the Department of the Navy or any other government agency.

Volunteer subjects were recruited, evaluated, and employed in accordance with the procedures specified in Department of Defense Directive 3216.2 and Secretary of the Navy Instruction 3900.39 series. These instructions are based upon voluntary informed consent and meet or exceed the provisions of prevailing national and international guidelines.

Trade names of materials and/or products of commercial or nongovernment organizations are cited as needed for precision. These citations do not constitute official endorsement or approval of the use of such commercial materials and/or products.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NAMRL SR89-2	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Aerospace Medical Research Laboratory 6b. OFFICE SYMBOL (If applicable) 24	7a. NAME OF MONITORING ORGANIZATION Naval Medical Research and Development Command
6c. ADDRESS (City, State, and ZIP Code) Naval Air Station Pensacola, FL 32508-5700	7b. ADDRESS (City, State, and ZIP Code) Naval Medical Command National Capital Region Bethesda, MD 20814-5044
8a. NAME OF FUNDING/SPONSORING ORGANIZATION NMRDC 8b. OFFICE SYMBOL (If applicable) Code 404	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Commanding Officer, NMRDC, Naval Medical Command, National Capital Region, Bethesda, MD 20814-5044	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO.: 63764A PROJECT NO.: 3M63764B995 TASK NO.: AB.082-7 WORK UNIT ACCESSION NO.:

11. TITLE (Include Security Classification)
(U) Development of three mobile field laboratories for the field acquisition of biomedical performance data

12. PERSONAL AUTHOR(S)
W.C. Hixson, E.A. Molina, G.D. Prettyman, and J.D. Grissett

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 8310 TO 8809	890613	25

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Naval aviation; Mobile laboratory; Biomedical tests; Cardiopulmonary; Acoustic; Cognitive; Performance; Vestibular

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Although research involving the performance of military performance can often be conducted in fixed laboratory installations, certain operational requirements mandate the collection of data at field sites remote from the laboratory. To address this problem, NAMRL has completed the design, development, and construction of three new Mobile Field Laboratories (MFL) for collection of biomedical performance data at various in-country military installations. One MFL is devoted to the acquisition of cardiopulmonary data, a second to vestibular data, and a third to the combined acquisition of acoustic and cognitive performance data. Each MFL, outfitted with its own diesel-driven power source, air conditioning system, and water service, is designed to operate under stand-alone conditions without the need for any form of shore-based support. This report describes the basic technical characteristics and operating features of the new MFLs.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL J. A. BRADY, CAPT MSC USN, Commanding Officer	22b. TELEPHONE (Include Area Code) (904) 452-3286 22c. OFFICE SYMBOL 00

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

S/N 0102-LF-014-6603

SUMMARY PAGE

THE PROBLEM

Although research involving the performance of military personnel can generally be conducted in fixed laboratory installations, there are times when data must be collected in the field. This requirement can arise when the research involves either environmental stressors that cannot be replicated in the laboratory, specialized military equipment or weapons systems that cannot be readily moved to the laboratory, or the need to acquire data on a noninterference basis from populations performing operational tasks remote from the laboratory.

FINDINGS

To address this problem, the Naval Aerospace Medical Research Laboratory (NAMRL) has completed the design, development and construction of three new Mobile Field Laboratories (MFL) for the collection of biomedical performance data at various in-country military installations. One MFL is devoted to the acquisition of cardiopulmonary-related data, the second to the measurement of vestibular-related performance data, and the third to the collection of auditory and cognitive performance data. In addition, two previously constructed MFL units have been modified to provide separate facilities for vision and cognitive performance testing. With these developments, NAMRL now has the capability for acquiring a wide range of multidisciplinary biomedical performance data at various military field sites.

RECOMMENDATIONS

Placement of the MFLs in the field to support new and current RDT&E work units will require 1) adequate and sustained funding for the operation and continued maintenance of each unit, 2) the assignment of qualified biomedical personnel to each MFL, and 3) training and indoctrination of these personnel on the specific tests to be implemented in each MFL and the procedures to be followed when securing equipment in preparation for transit operations.

Acknowledgments

The NAMRL staff wishes to acknowledge CAPT W. M. Houk for the impetus he gave to the development of the new MFL units and CAPT J. O. Houghton for the guidance and support he provided during the design and construction phases of the project.

Acknowledgment is also made of Denson Engineers, Inc., for providing the engineering services required to convert the NAMRL design requirements for each MFL to working construction drawings; Gulf Electric Construction Co., Inc., who served as the prime contractor for the MFL construction; and Bayou Mechanical Contractors, Inc., Coastal Generators, Inc., Dorsey Trailers, Inc., R.N. Pyle Mechanical Contractors, and Specialty Contractors, Inc., for their subcontracting services.

Appreciation is also offered to the many members of the Navy Public Works Center who participated in the design, construction, and acceptance phases of the project. Special thanks is extended to R. G. Hinson who supervised preparation of the architectural and engineering contract specifications, Lt. A. J. Cox who served as project manager, and W. Simpson who served as chief inspector.

Of the many NAMRL staff members who participated in the preparation of functional design specifications for the three new MFL units, special recognition is extended to C. E. Williams, G. B. Thomas, and D. W. Maxwell for the Acoustic facility; G. R. Griffin and LCDR T. R. Morrison for the Cognitive Performance facility; CDR G. R. Banta and L. G. Meyer for the Cardiopulmonary unit; J. M. Lentz, F. E. Guedry, Jr., J. W. Norman, and G. T. Turnipseed for the Vestibular MFL; and CAPTs L. B. Nichols and O. G. Blackwell, II, for project coordination contributions. Special appreciation is extended to A. N. Dennis, Jr., for his many technical contributions during the design, construction, and acceptance testing phases of the project. Acknowledgment is also made of the photographic documentation contributions of R. C. Barrett to the MFL project, and the typing and report preparation skills of N. Davis.

Manuscript submitted for review on September 14, 1988.

INTRODUCTION

Although research involving the performance of military personnel can generally be conducted in fixed laboratory installations, there are times when data must be collected in the field. This requirement can arise when the research involves either environmental stressors that cannot be replicated in the laboratory, specialized military equipment or weapons systems that cannot be readily moved to the laboratory, or the need to acquire data on a noninterference basis from populations performing operational tasks remote from the Laboratory.

The Naval Aerospace Medical Research Laboratory first demonstrated its interest in the development of special mobile laboratories (MFL) for the collection of performance data under field conditions in 1956. At that time, the Navy was concerned with the auditory and nonauditory effects of the noise exposure received by members of the flight-deck crew aboard aircraft carriers. To address this problem, NAMRL (then known as the U.S. Naval School of Aviation Medicine) contracted with the Central Institute for the Deaf to design a mobile acoustic laboratory constructed on a standard (8 ft by 40 ft) semitrailer bed (1). The main elements of the laboratory included a 10-man, semi-automated, group audiometer and a small-scale psychomotor test battery. This laboratory was used to collect aircrew auditory performance data aboard aircraft carriers as well as at various ground-based squadron locations.

Construction of two additional mobile laboratories was initiated in the early 1980s for the acquisition of visual performance data in the field. These trailers became operational late in 1982 and included all instrumentation required to implement a comprehensive Vision Test Battery (2). These units enabled NAMRL to acquire extensive performance data from naval aviators undergoing flight training at the Tactical Aircrew Combat Training System (formerly the Air Combat Maneuvering Range).

This paper addresses three new MFLs developed by NAMRL for the collection of biomedical performance data at various in-country military installations. One MFL is devoted to the acquisition of cardiopulmonary-related data, the second to vestibular related performance data, and the third to both auditory and cognitive performance data. Each MFL has been designed to operate on a self-sufficient basis providing all utility services including electrical power, heating and air-conditioning, storage tanks for potable water, and holding tanks for waste water. We present a brief overview of the basic design and construction features of the MFL units and their biomedical testing facilities.

BASIC DESIGN AND CONSTRUCTION FEATURES

MECHANICAL SYSTEMS

A photograph of the first completed MFL at the time of its delivery to NAMRL is shown in Fig. 1. Construction of each unit was based on the use of a standard Type IV, closed-van, riveted body, semitrailer. The overall dimensions were 48 ft x 8.5 ft x 13.5 ft. Each MFL is equipped with a 20,000-lb tubular tandem-axle, 3-leaf springs rated for a maximum capacity of 11,200 lbs, and an air-ride sliding suspension system to minimize road

Figure 1. Photograph taken at the time of delivery of the first Mobile Field Laboratory (MFL) to NAMRL.

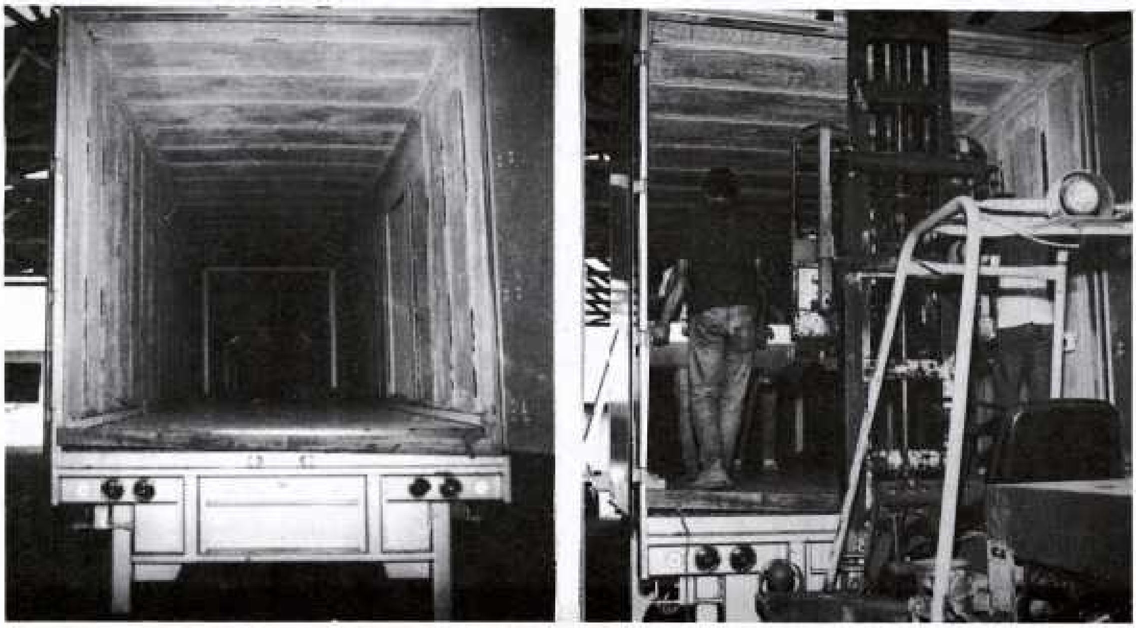

Figure 2. Views of MFL interior showing trailer side post construction after spraying with acoustic damping material (left) and the 4-in thick acoustic panels in the process of being installed (right).

shock effects on the biomedical testing equipment. With this configuration, each MFL is rated for a gross vehicle weight of 65,000 lb and a maximum payload of 55,000 lb.

Each unit has a platform floor constructed of 1.375-in laminated hardwood laid over a 0.25-in aluminum subfloor that is supported by steel cross-sill beams spaced on 12-in centers. Longitudinal support for the beams is provided by a 9-in extruded aluminum rail. Support of the wall and ceiling is provided by side posts and curved roof braces spaced on 24-in centers. The exterior skin, consisting of roof, side, and end panels, is constructed of .050-in aluminum alloy riveted directly to the side posts and roof braces. Sound and vibration dampening of these panels was provided by application of a semi-rigid foaming material to the interior surfaces of the trailer. A rear view of an MFL showing the internal side posts and roof braces following application of the dampening material is shown at the left in Fig. 2.

To minimize the transmission of exterior acoustic noise to the MFL testing spaces, an internal shell was constructed of standard, commercially available, 4-in thick acoustic panels, which lined the walls, end panels, floor, and ceiling. A construction photograph showing one of these panels being readied for erection is shown at the right in Fig. 2. Additional isolation was provided by a dropped ceiling constructed of 3-in thick acoustic panels. The area between the two ceiling panels was used to house ductwork for the heating and air-conditioning systems and cableways for the electrical power and instrumentation wiring. Photographs taken after installing the 4-in thick deck, wall, and roof acoustic panels and related air-conditioning ductwork, but before installing the 3-in thick dropped ceiling, are shown in Fig. 3.

In certain areas requiring additional acoustic attenuation, a second interior acoustic shell or room was constructed with 3-in thick acoustic panels. All interior and exterior doors utilized acoustic panel construction with heavy-duty hinges, double-glazed windows, and neoprene door seals. To provide weather protection for the acoustic exterior doors during MFL transportation, a large-scale door (flush with the external skin of the trailer) was used to cover the acoustic entrance doors. Access to each exterior door is provided by a portable stairway/railing assembly that can be dismantled and stored below the trailer undercarriage during transit. As shown in Fig. 4, each MFL is equipped with two different styles of entrance ladders; one with the steps parallel to the trailer frame, the other with steps at right angles to the entrance door.

Leveling of the semitrailer at a field location is achieved by four hand-cranked, gear-type, vertical lift, telescopic landing gears with non-rotating, self-leveling skid pads (see Fig. 5). Eight spirit levels, attached to the sides and ends of the trailer, serve as leveling aids.

ELECTRICAL SERVICE

Two electrical alternators, driven by diesel engines, are used to power each MFL. Each water-cooled diesel engine is a 4-cycle, 4-cylinder, vertical, inline design rated at 25.5 brake hp at 1900 rpm. One alternator is rated for a 15-kW, 18.7-kVA, 120/208-Vac, 3-phase, 4-wire, 60-Hz load with a 0.8 power factor based on continuous duty at 80 ^{o}C rise over

Figure 3. Interior of MFL after installation of the 4-in thick floor, sidewall, and ceiling acoustic panels but prior to installing the 3-in thick dropped ceiling panel.

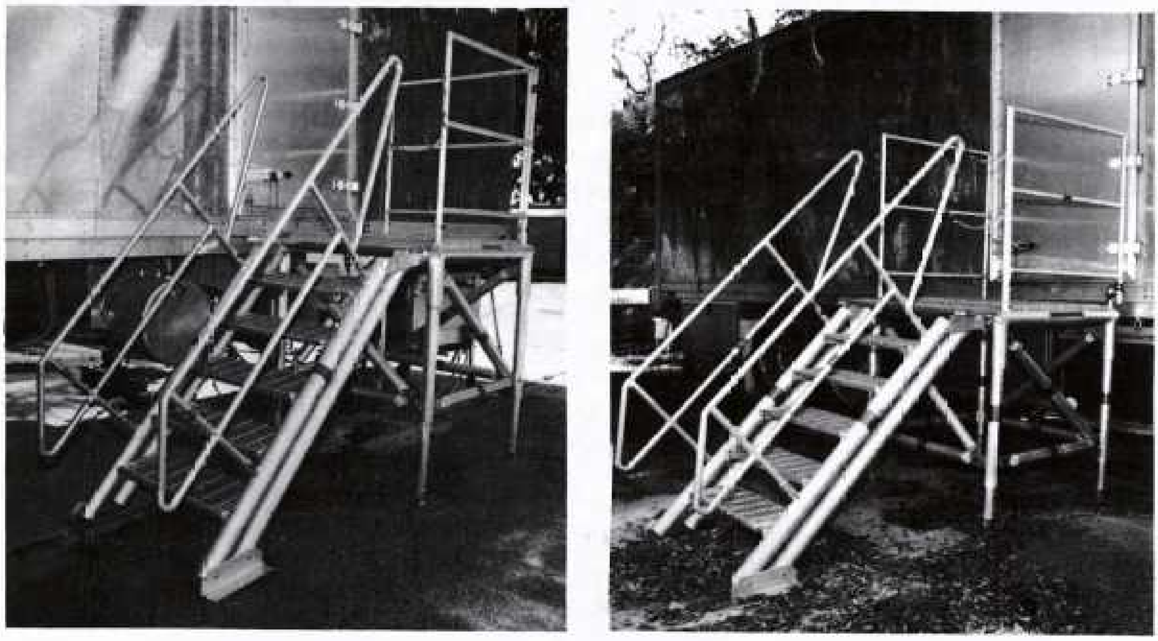

Figure 4. Curbside view of the two different modular ladder and staircase assemblies provided with each MFL. One ladder is constructed to allow access to the entrance door with stairs parallel to the trailer (left) and the other with stairs perpendicular to the trailer (right).

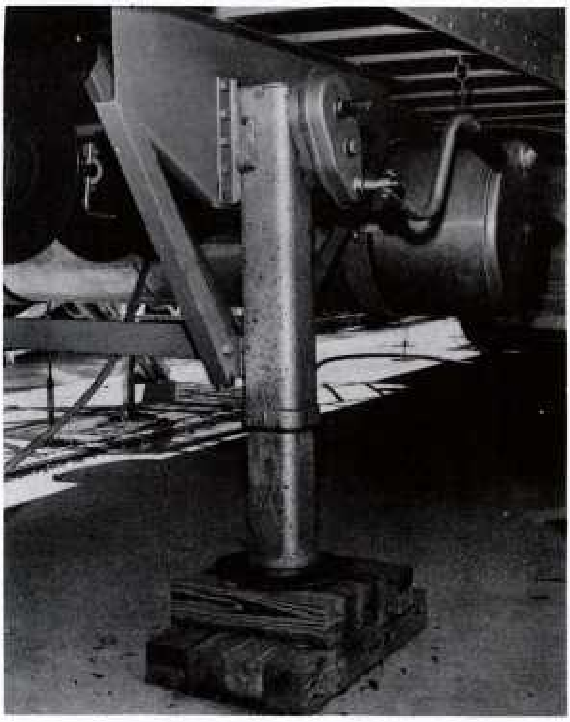

Figure 5. Views of two-speed, gear-driven, landing jack assemblies used to level the MFL units.

40 °C ambient. This unit is used to power the heating, airconditioning, and interior lighting systems. The second alternator is used to power the MFL biomedical instrumentation and is rated for a 10-kW, 10-kVA, 120/240-Vac, single-phase, 3-wire, 60-Hz load with a 1.0 power factor based upon the same duty and temperature conditions. For this unit, two static-magnetic transformers rated at 5 kVA each provide voltage regulation for the instrumentation systems. These transformers provide an output voltage regulation of +/- 0.5% for +/- 20% changes in input voltage.

During transit, the two alternator systems are separately attached to the MFL undercarriage by welded support-brackets. Four wheel-mounted jack assemblies allow each alternator to be lowered from the undercarriage and manually moved to a location remote from the MFL (Fig. 6). A 50-ft flexible power cable is used to interconnect each alternator to the MFL. The same cables, terminated with quick-disconnect connectors, can also be used to interconnect the MFL units to a standard utility power source when available. Two reel-mounted, flexible fuel lines interconnect each diesel engine to a 110-gal fuel tank. Separate fuel-feed and fuel-return lines are used to minimize diesel operating problems caused by airlocks entering the fuel system (Fig 7).

Distribution of the two power services to the interior of each trailer is provided by three, wall-mounted, circuit breaker panels. Two of these panels distribute the single-phase instrumentation power: one receives the external power and energizes the voltage regulation transformers, and the second distributes the regulated voltage to the MFL spaces. A third panel is fed by the 3-phase power source and distributes all 115/208 Vac power required by the heating, airconditioning, lighting, and water service systems. Photographs of the three junction boxes taken during and following MFL construction are shown in Fig. 8.

FRESHWATER AND WASTEWATER SERVICE

Potable water is supplied to each MFL from a 110-gal stainless steel storage tank mounted to the trailer undercarriage. Water pressure to distribute the water within the MFL is provided by an automatic, marine-type pump driven by a 115 Vac, 1/2 hp electric motor. A photograph of the storage tank and the immediately adjacent water pump assembly is shown at the left in Fig. 9. Each pump incorporates a pressure-actuated cutoff switch to provide pump protection in the event of a dry tank. Check-valves allow the pump to be bypassed when water can be supplied from a fixed utility service. Hot water is supplied by small electrically heated water storage tanks installed within each MFL.

Storage of wastewater is also provided by a 110-gal tank, shown at the right in Fig. 9, that can be either gravity drained by standard mobile home flexible hoses or pump drained from an external source. In the case of the Vestibular and Acoustic MFLs, freshwater is required only for the operation of small sink lavatories. For the Cardiopulmonary unit, water is required for sink, shower, and commode facilities.

To maintain operation of the water system during freezing conditions, electrical heat-trace cables are wrapped around the main pump assembly, the two water storage tanks, and all interconnecting plumbing lines. In turn, the cables are wrapped with a 0.5-in thick foam-like neoprene material for

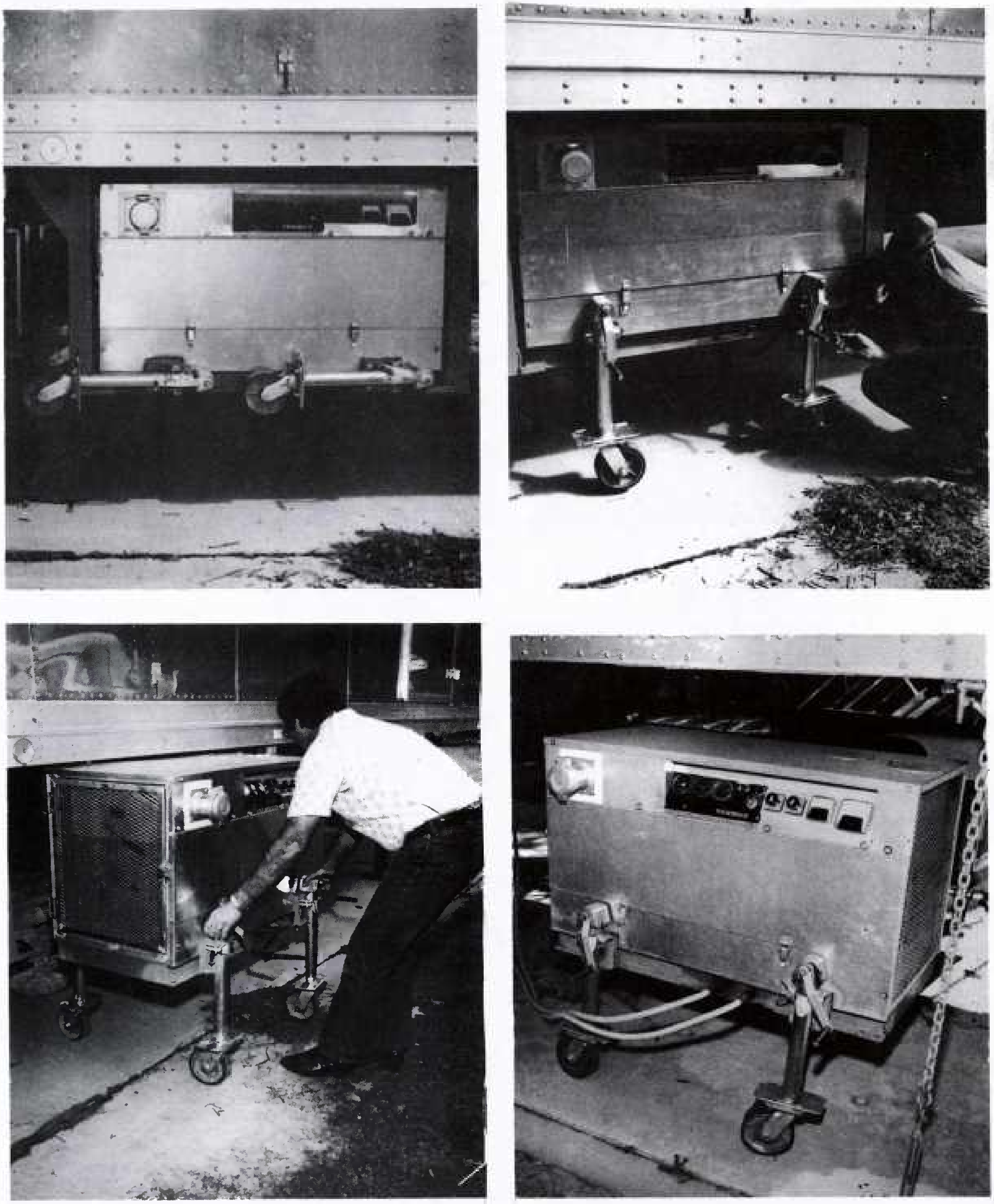

Figure 6. Photographs of one of the two diesel-powered alternators while still fixed to the MFL undercarriage (top left); in the process of lowering and adjusting its wheel-type support legs (top right); its removal from the undercarriage (bottom left); and its final setup for operation (bottom right).

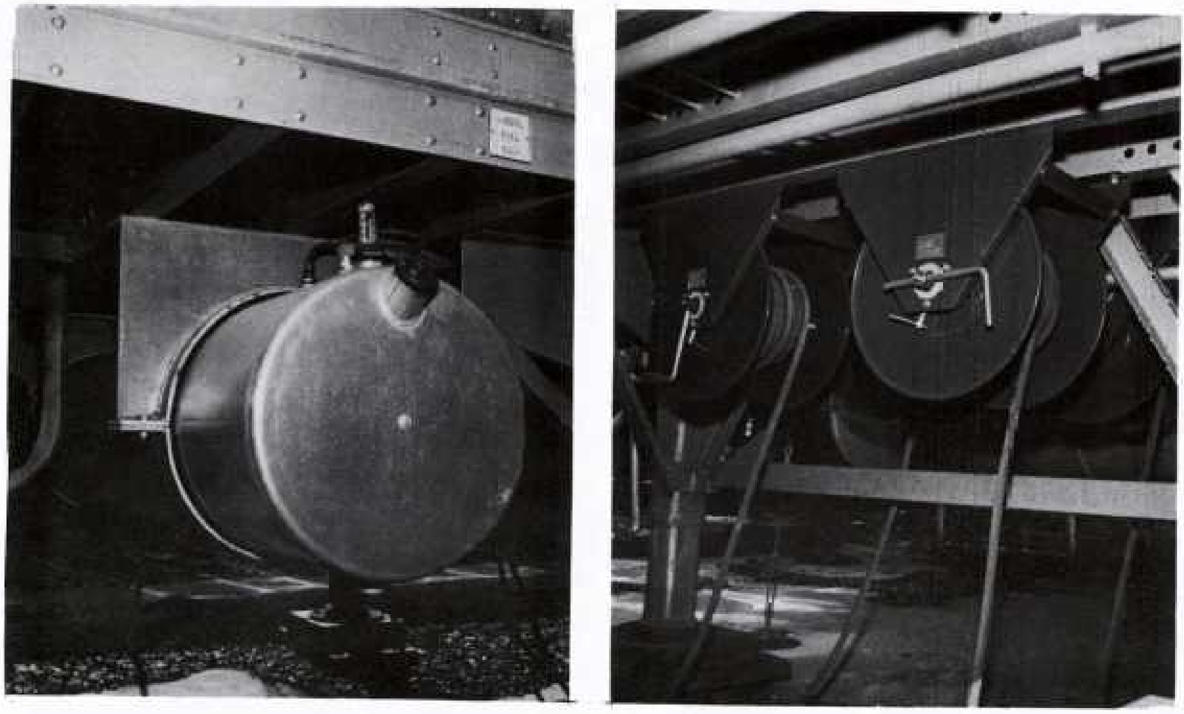

Figure 7. View of the 110-gal diesel fuel tank (left) and the dual fuel supply and return lines that feed the diesel-powered alternators. The return line is used to minimize the chance of air locks entering the fuel lines.

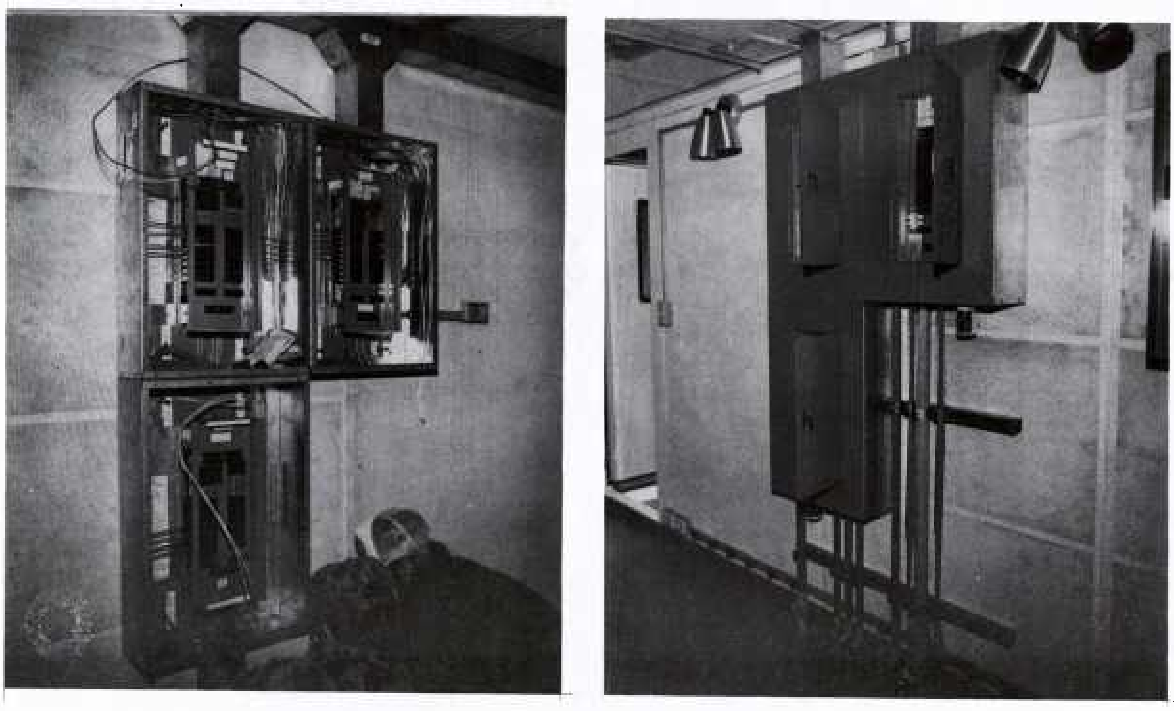

Figure 8. Interior electrical power distribution boxes during (left) and upon completion of (right) MFL construction.

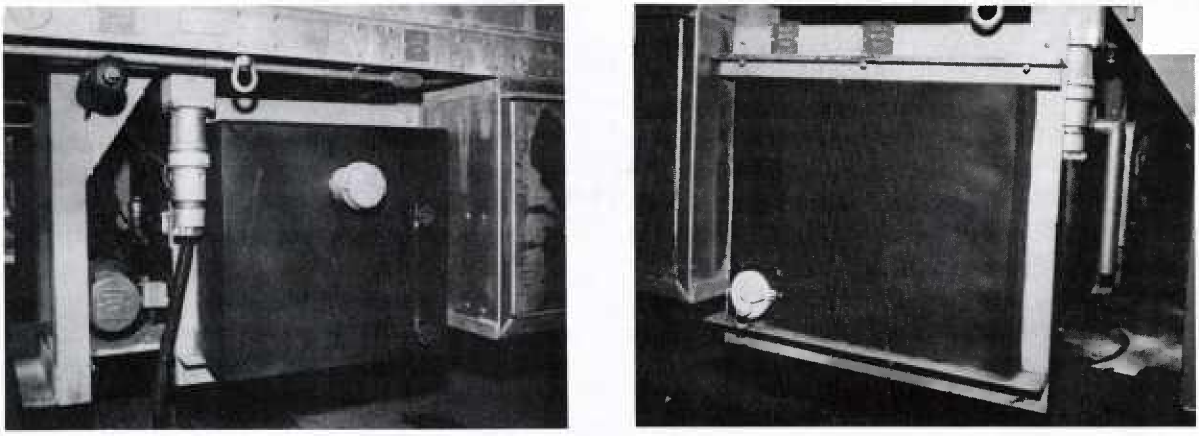

Figure 9. Photographs of undercarriage-mounted tanks used to store potable freshwater (left) and wastewater (right). The pump mechanism used to pressurize the water system is at the left of the freshwater tank.

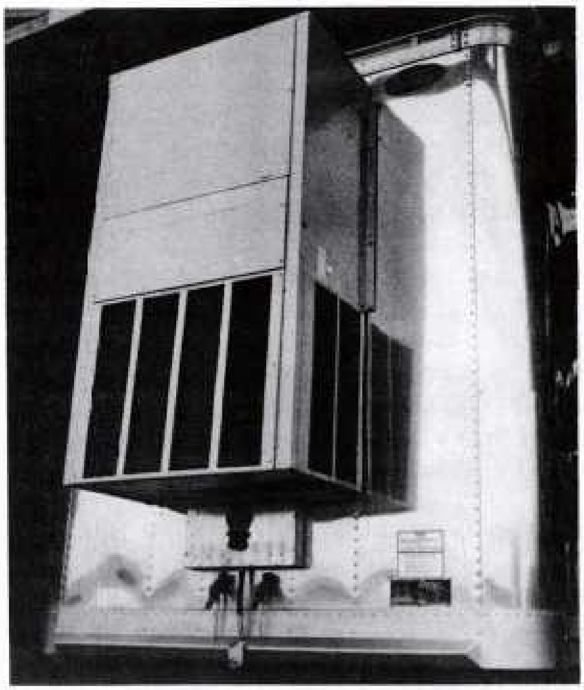

Figure 10. View of heating and air conditioning unit installed on the front vertical surface of each MFL. The unit is isolated from the trailer frame by neoprene gaskets to minimize the transmission of acoustic and vibration noises to the MFL superstructure.

additional insulation. Operation of the heat-trace system was controlled by an external thermostat mounted adjacent to the water pump assembly.

HEATING AND AIR-CONDITIONING

Climate control for each MFL is provided by a single heat pump installed on the front vertical exterior wall (Fig. 10). This unit requires a 208-Vac, 3-phase, 60-Hz power source for operation. Cooling is provided by a compressor rated at 4 tons; heating is furnished by a 9-kW electrical heater rated to produce an output of 23,100 BTU at 208 Vac input. Defrost circuitry minimizes the chance of compressor icing when outside temperatures fall below 4.4 °C (40 °F).

To minimize the transmission of air conditioner vibrations to the MFL, the face of the heat pump structure is insulated from the trailer frame by neoprene strips installed along the perimeter of the heat pump mounting frame. In addition, flexible nonmetallic ducting is used to connect the heat pump output vent to the interior metallic ductwork that distributes air throughout the MFL. The interior of the metallic ductwork was lined with acoustic damping material to further reduce the transmission of acoustic noise from the air conditioner system to the MFL interior.

MISCELLANEOUS FEATURES

Each MFL is equipped with two 27 x 55 x 96-in plywood-lined aluminum storage compartments. In the Acoustic/Psychology and Vestibular units, one compartment is installed on the undercarriage immediately in front of the trailer wheels, and the other to the rear of the trailer wheels. For the Cardiopulmonary MFL, one compartment was installed on the undercarriage and the other on the rear vertical wall because undercarriage space was required for the plumbing associated with the head facility installed at the very rear of this trailer. The primary function of these units is the storage of the entrance stairs and landings as shown at the left in Fig. 11. Two small cylindrical PVC tubes, placed cross-wise on the trailer undercarriage, are used to store 8-ft long copper-clad steel rods used to electrically ground the MFL trailer frame and alternator frames at field locations. Telephone service to the trailer interior is provided by an external waterproof junction box. A second junction box, shown at the right in Fig. 11, will enable pulling spare cables through entrance conduit to the trailer interior for electrical control functions that may be implemented in the future.

INTERIOR CONFIGURATION OF EACH MFL

ACOUSTIC/COGNITIVE PERFORMANCE MFL

A simplified sketch of the floor plan for this MFL is shown at the top in Fig. 12. The cognitive performance facilities are located at the front and the acoustic facilities at the rear of the trailer. The acoustic area includes a six-person soundproof booth, a one-person soundproof booth, and a centrally located control room. Each soundproof booth is constructed of 3-in thick acoustic panels that were erected on the inside of the 4-in thick acoustic panels that line the walls, floor, and ceilings of the MFL structure. This acoustic treatment of the test booths resulted in outside noise attenuation ranging from 38 dB at 125 Hz to 93 dB at 8000 Hz. Two

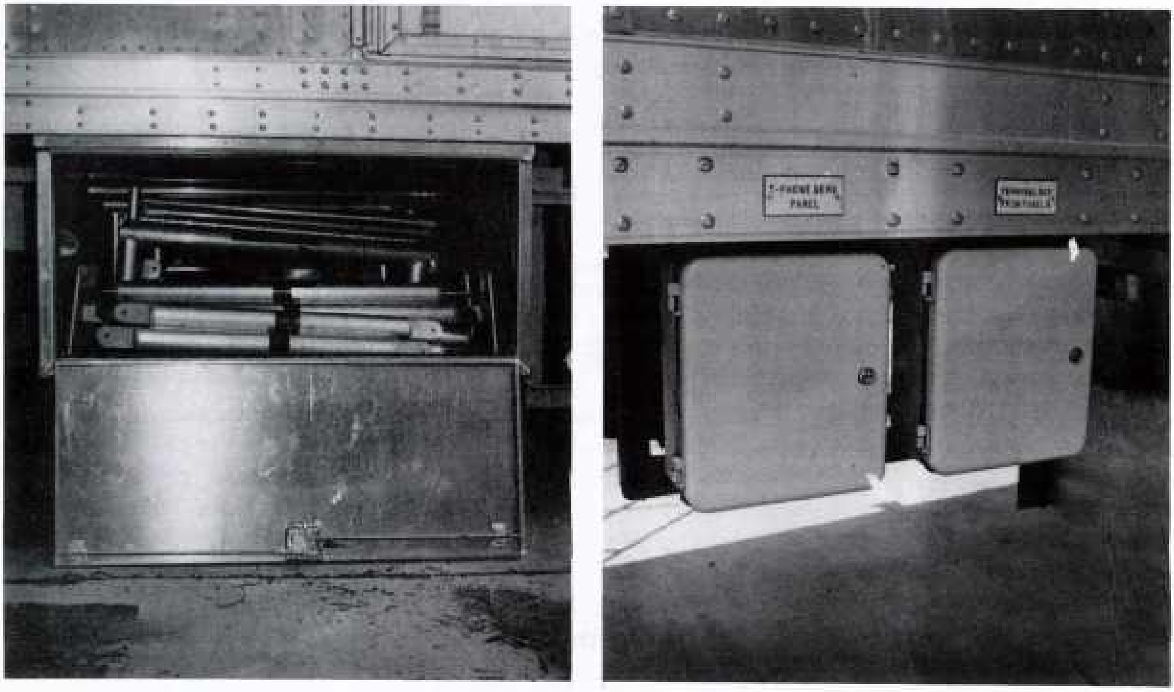

Figure 11. Views of storage compartment installed on the MFL undercarriage after storing one ladder assembly (left) and the two external junction boxes used to provide telephone service and remote electrical control lines to the MFL interior.

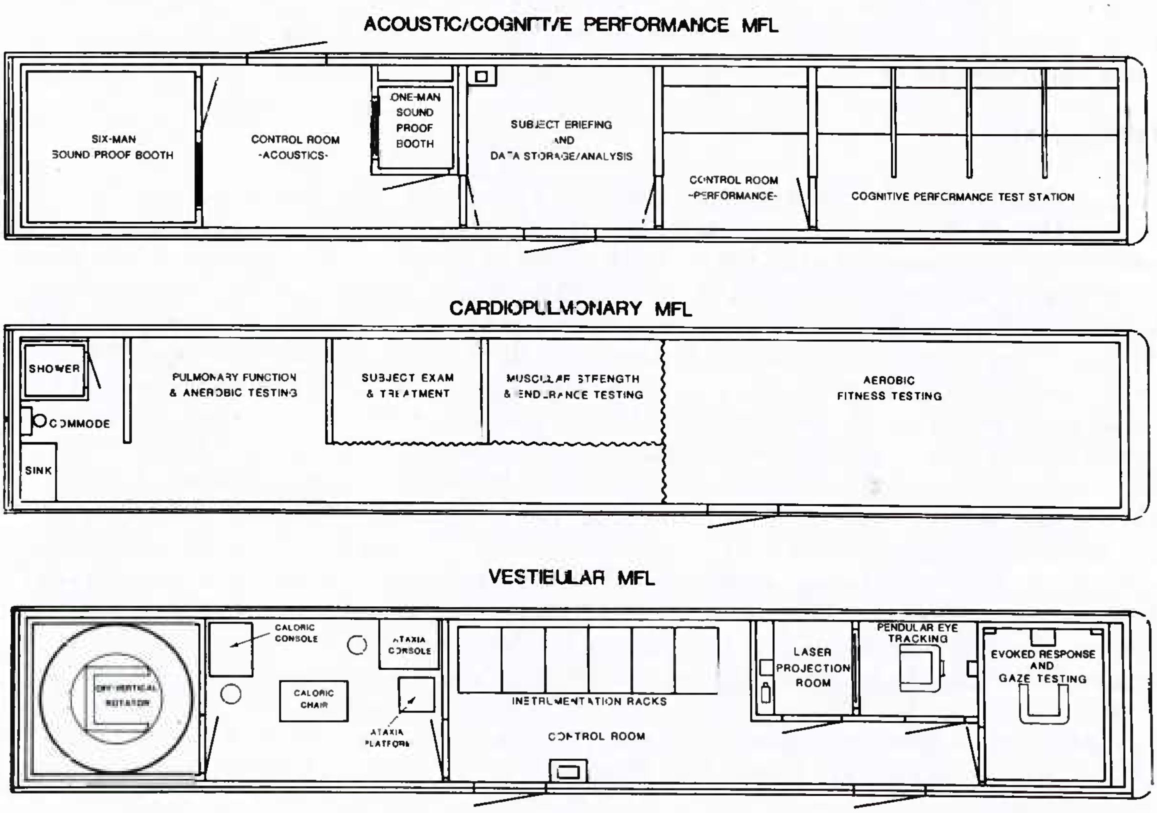

Figure 12. Floor plan layout of each of the three MFL units.

photographs of the acoustic control room, which show test equipment setup for a study of drug effects on auditory performance, are shown in Fig. 13.

A general-purpose room, used to brief volunteer subjects and to store/analyze test data collected within the MFL, is located immediately forward of the acoustic testing area. The cognitive performance test facilities consist of a control room and four individual testing stations (Fig. 14). Each test station, designed for general-purpose applications rather than for specific test setups, consists of a built-in subject table and an overhead shelf to house the cognitive performance stimulus/response testing equipment. Visual shielding of one subject from another is provided by lightweight, partition panels that separate the test stations. The control room and test stations are electrically interconnected with RS-232 interface cables to provide for remote as well as local control of the computer-controlled cognitive performance test battery selected for a given research application.

CARDIOPULMONARY MFL

The layout of this MFL, shown at the center in Fig. 12, is of semi-open construction without any full wall-to-wall partitions present except for the rear room, which houses the sink, shower, and commode facilities. As with the Acoustic/Cognitive Performance MFL, the testing stations within this trailer were designed for general purpose applications rather than for specific biomedical test instruments or devices. Separate areas were provided for pulmonary function and anaerobic testing, subject examination and treatment, muscular strength and endurance testing, and aerobic fitness testing (Fig. 15). The actual equipment that will be installed in these areas will vary according to the research requirements of each project implemented within the MFL.

VESTIBULAR MFL

The layout and assignment of testing spaces in the Vestibular MFL, shown by the floor plan at the bottom in Fig. 12, is highly dedicated compared to the space assignments in the other MFLs. This arises primarily because the equipment used in the vestibular tests selected for implementation in this MFL have relatively rigid constraints in terms of the physical size of a room required to hold a specific device or testing setup, the acoustic isolation of the room, or its lightproof qualities. For example, the rearmost section of the MFL contains a high-performance, servomechanism-controlled motion device, identified as the Off-Vertical-Rotator (OVR), which is used to gain measures of semicircular canal and otolith function and related spatial orientation performance. The OVR contains a chair that can rotate a subject under different velocity profiles about an axis ranging from Earth-vertical to 30° from vertical, a cylindrical visual surround used to reflect optokinetic stimuli, and a laser projection assembly to calibrate eye motions. Several photographs of the OVR as viewed from the room entrance door are shown at the top in Fig. 16. This device is a permanent installation that requires a given amount of floor space, a high-degree of sound isolation (to minimize the introduction of external acoustic noises that might cue the subject as to his instantaneous spatial orientation), and lightproof doors (to eliminate visual cues). Accordingly, the OVR chair is mounted in a lightproof acoustic booth installed within the 4-in thick acoustic walls of the MFL.

Figure 13. The Acoustic MFL facility photographed from the control room showing the six-person test booth (top) and the one-person test station (bottom).

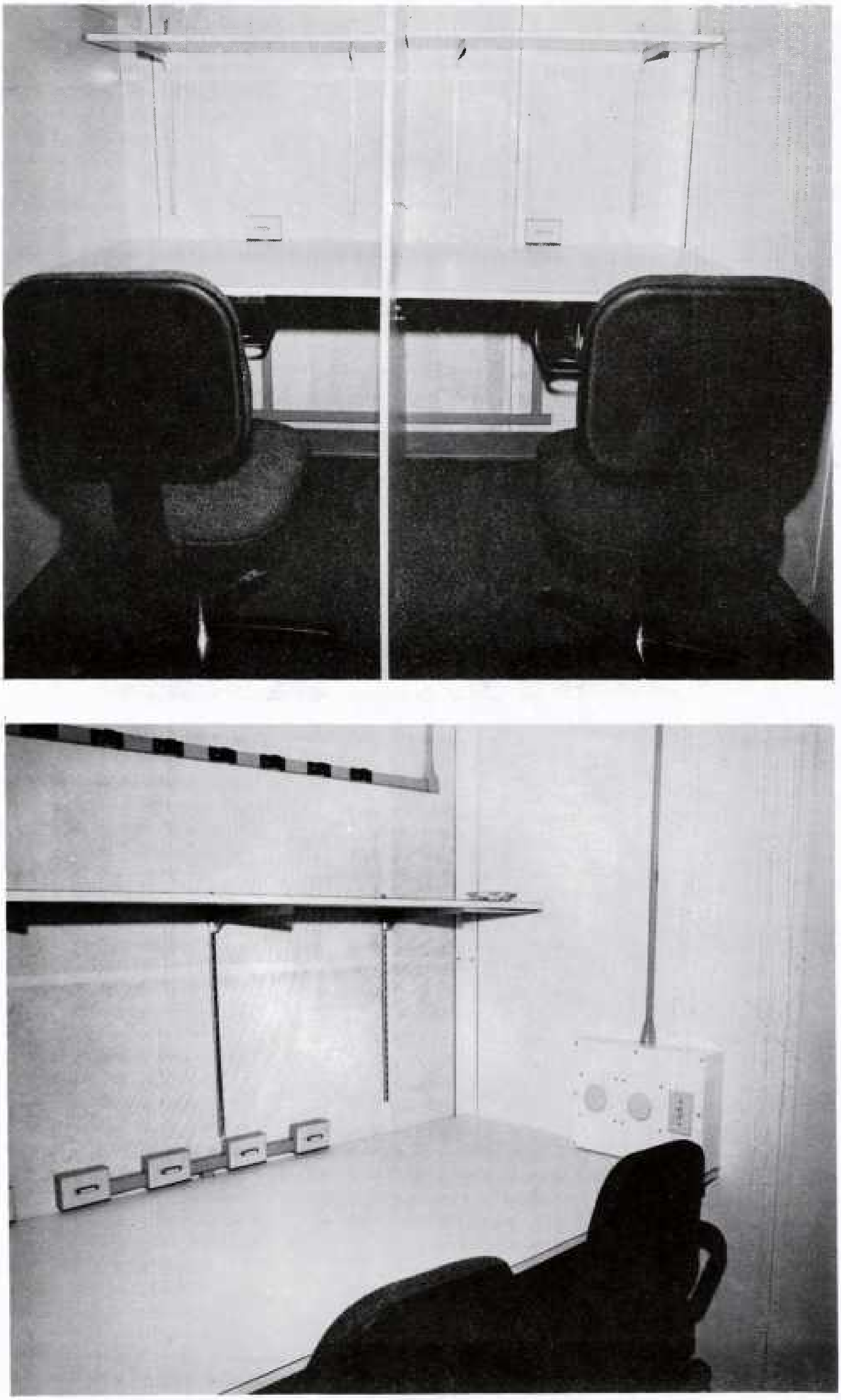

Figure 14. The Cognitive Performance MFL showing two adjacent subject booths in the four-person testing area (top) and the related control room (bottom).

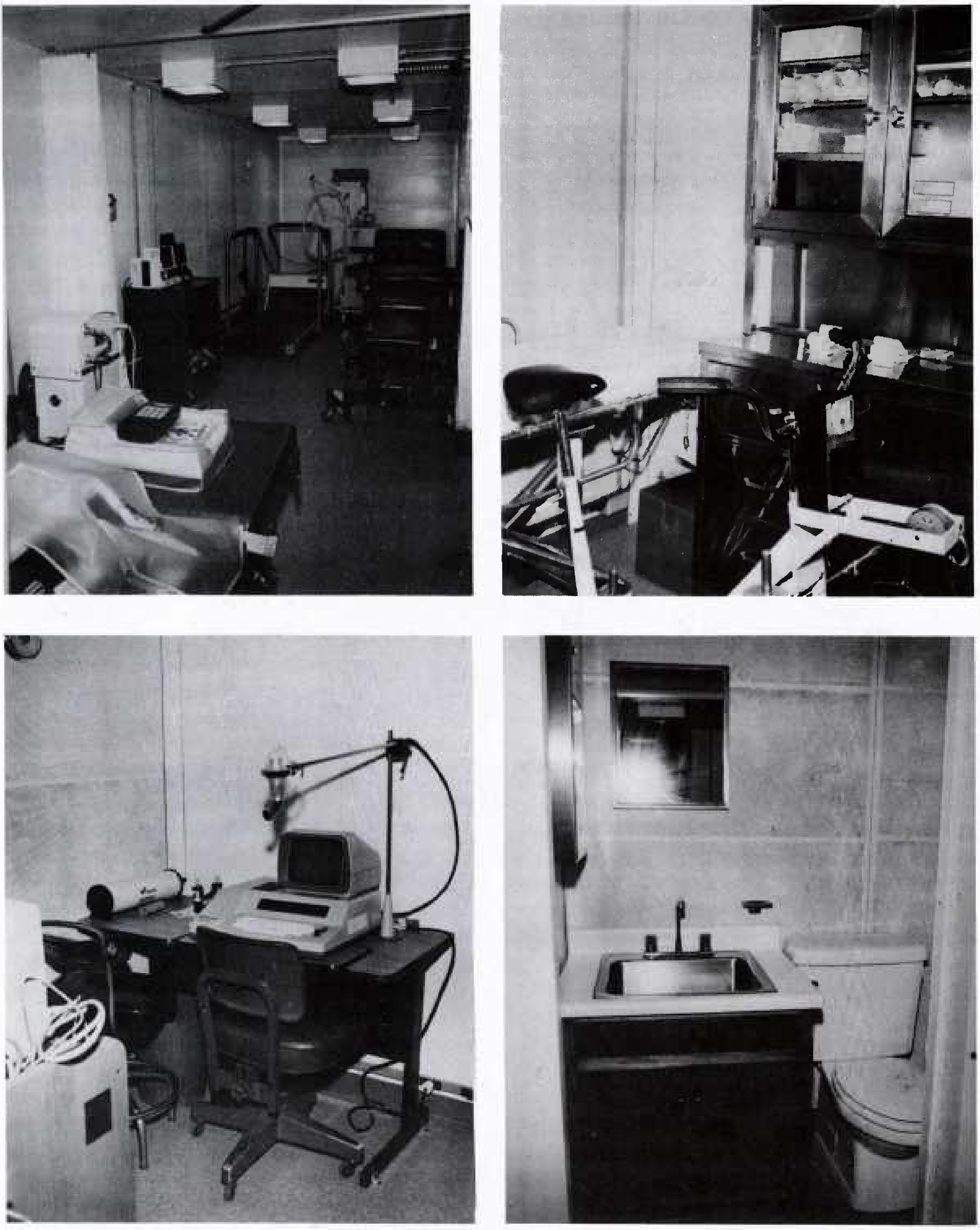

Figure 15. Photographs of the Cardiopulmonary MFL showing the anaerobic fitness testing room (top left); the muscular strength and endurance testing room (top right); the pulmonary function and aerobic testing room (bottom left); and the head facility (bottom right).

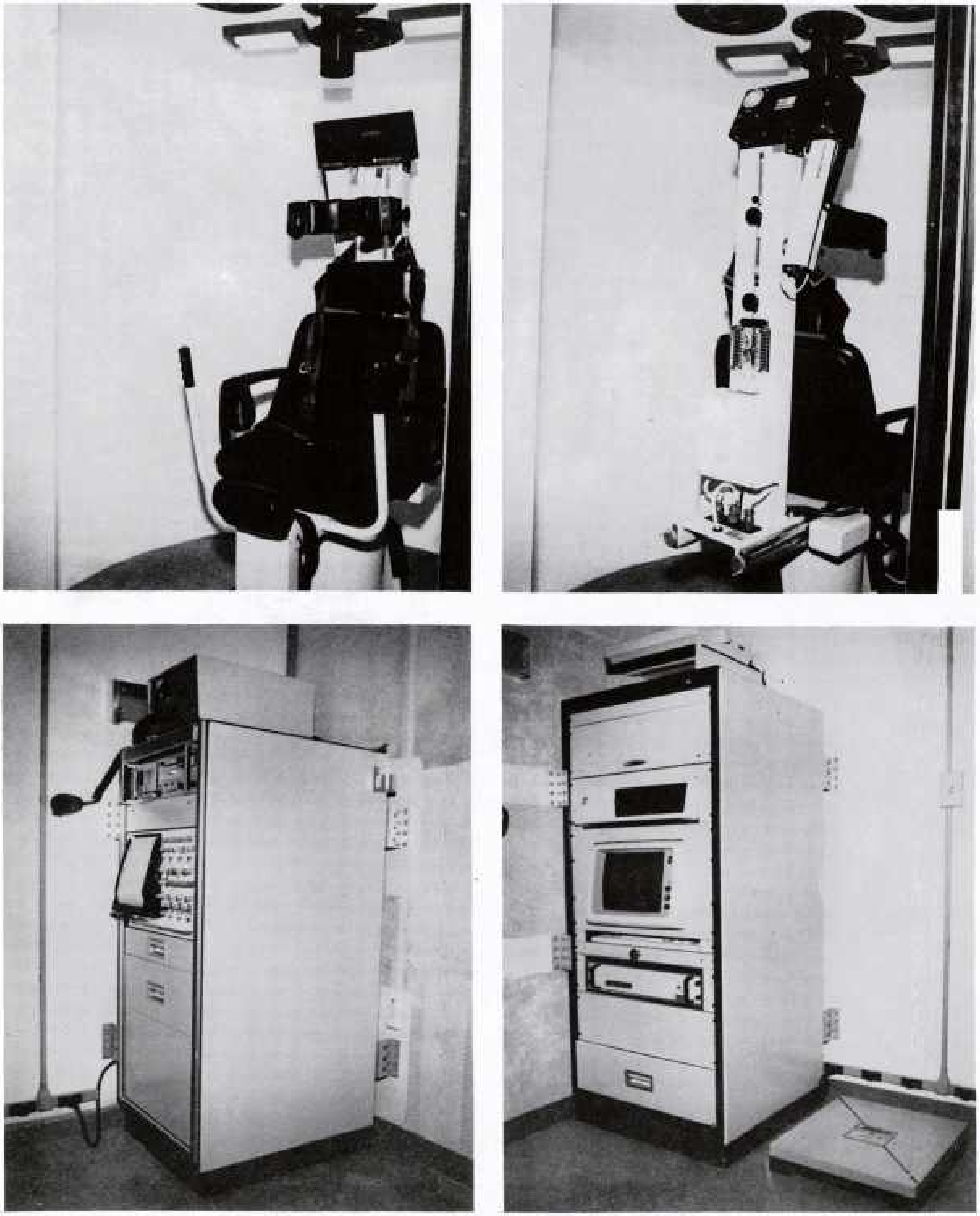

Figure 16. Interior of the Vestibular MFL showing the front (top-left) and rear (top right) of the Off-Vertical-Rotating Chair; the air caloric instrumentation rack (bottom left); and the ataxia instrumentation rack (bottom right).

The room adjacent to the OVR installation houses equipment for two different biomedical test applications. The back section is used to acquire data produced by air-caloric irrigation of the ears and has the primary function of identifying individuals with asymmetric semicircular canal responses. The console used to acquire the caloric data is shown at the bottom left in Fig. 16. The forward section of the room contains a commercially available biomechanics platform and its related instrumentation that is used to acquire data describing the static postural equilibrium capabilities of an individual. The console and the ataxia platform which the subject stands on is shown at the bottom right in Fig. 16.

Specialized requirements in the vestibular MFL are also reflected in the two rooms used to implement either Pendular Eye Tracking or Malcolm Horizon Tracking studies. In one room, a seated subject faces a 4-ft x 6-ft rear projection screen. The second adjoining room contains a laser that projects a beam through a two-axis, servo-controlled mirror galvanometer assembly onto the rear-projection screen. For the Pendular Eye Tracking, the corneo-retinal potential method is used to measure eye motions while the subjects follow the moving target beam with his eyes. For Malcolm Horizon studies, the laser beam is modulated to produce a horizontal line that can be rotated about either the pitch or roll axis while the subject attempts to maintain the laser line in a fixed orientation with a joystick-type controller. A view of a subject instrumented for a Pendular Eye Tracking test is shown at the top left in Fig. 17. The laser scanner-assembly used to generate the target motions is shown at the top right in the same figure.

Two different types of tests are conducted in the room at the very front of the MFL; one involves a performance-based measure of gaze capability and the other evoked-response measures of sensory/cognitive performance. In the gaze test, the subject identifies visual stimuli presented on light-emitting-diode (LED) displays that are spaced so as to require 80° gaze shifts in either the horizontal or vertical plane. A view of the wall containing the LED displays used in the gaze function test is shown at the bottom left in Fig. 17. For the evoked-response test setup, standard, commercially available equipment is used to average responses produced by auditory, visual, and somatosensory stimuli. A photograph of the control console and stimulus generator, installed in one of the control room racks, is shown at the bottom right in Fig. 17.

The centrally located control room in the MFL houses six electronic instrumentation racks that contain the equipment and test instruments required to operate and control the majority of the remotely located testing stations. The main elements of the control system include two complete data acquisition systems. Each system has a stand-alone computer, hard-disk, analog filter, chart recorder, multiprogrammer instrumentation interface, and graphics printer; audio communications and closed-circuit TV monitoring equipment; test equipment for the maintenance and calibration of the electronic components of the system; control electronics for the OVR and evoked-response test setups; and a removable patch panel assembly that allows an operator to readily change from one experimental configuration to another in the event of either equipment failure or new testing requirements. The six racks that house this bioinstrumentation equipment are shown in Fig. 18.

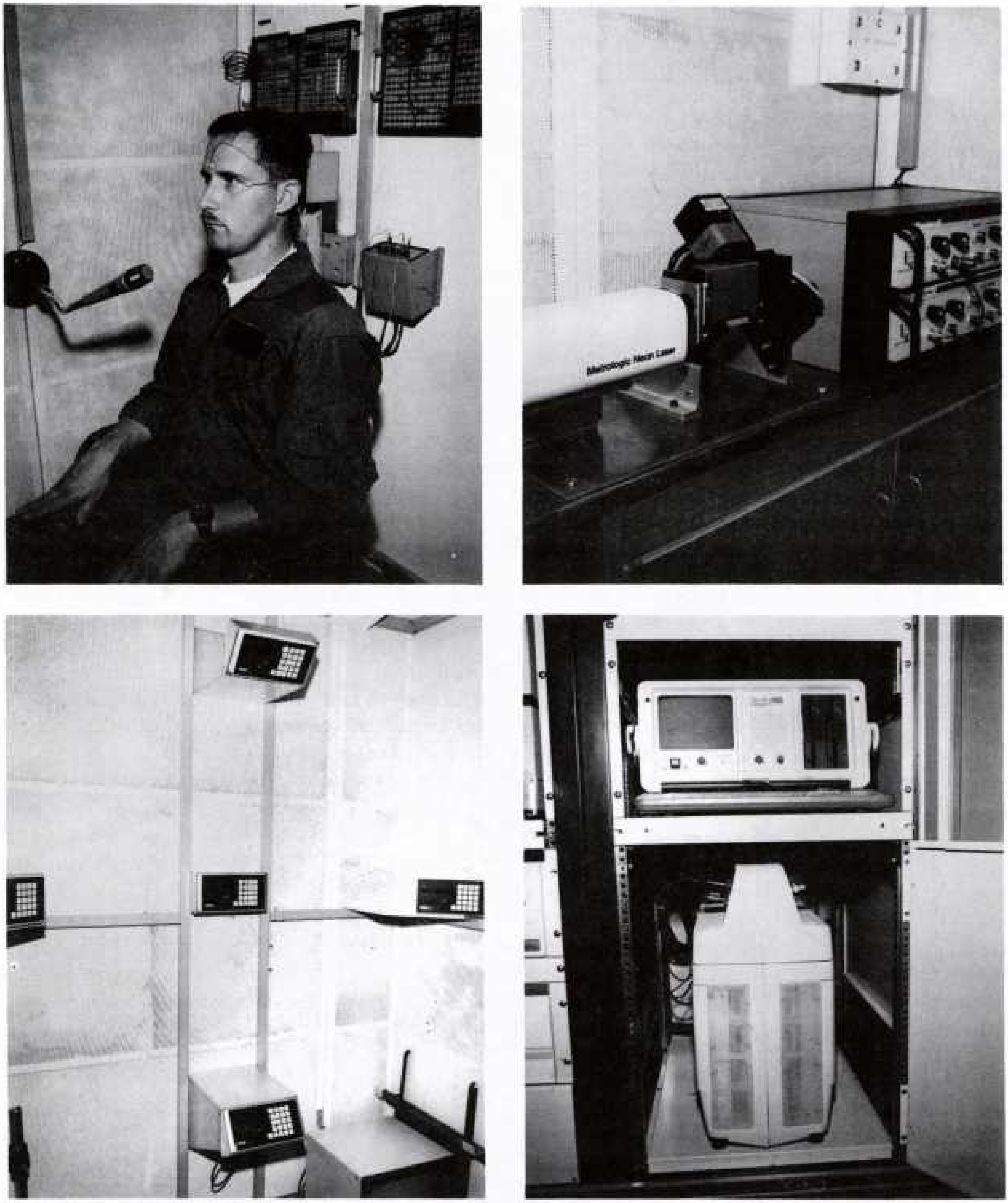

Figure 17. The Vestibular MFL showing the Pendular Eye Tracking (PET) room with an instrumented subject (top left); the laser projection room used to generate the PET target motions (top right); the Gaze Testing room used to implement the VORPET test (bottom left); and the evoked-response instrumentation installed in the control room (bottom right).

Figure 18. Photograph of the six instrumentation racks installed in the control room of the Vestibular MFL. These racks house two stand-alone data acquisition systems and related equipment required to operate and control the various biomedical tests implemented in the MFL.

SUMMARY AND RECOMMENDATIONS

The laboratory has fully met its objective of developing three self-contained MFLs that can readily acquire biomedical performance data from a variety of in-country field locations. At the present time, the units are being used locally to acquire data that will be used to validate a large multidisciplinary test battery developed by NAMRL to evaluate the effects of different stressors on pilot performance. Placement of the units in the field will require the assignment of trained biomedical personnel to each MFL; indoctrination of these personnel on the specific tests to be implemented in each MFL; and staff familiarization with the procedures to be followed when securing MFL equipment in preparation for transit operations.

A last point concerns the need for adequate funding for both the operation and continued maintenance of each MFL. An estimate of the annual funding required to operate four MFL units (the three new MFL units and a previously developed Vision MFL) is presented in Table I. These data derive from the assumptions that all four MFLs will be moved as a group to a preselected in-country field site four times per year; that each field trip will last for approximately 30 days; and that additional full-time

Table 1. Estimated Annual Operating Cost for Four MFLs with a Full-time Civilian Staff and Four 30-day Field Trips Per Year.

PERSONNEL COSTS: Includes Salary, Acceleration, and Overhead	
1. Vestibular MFL	
2 ea. GS-9 Data Collection Technician, 57 K ea.	$ 114 K
2. Acoustic/Cognitive Performance MFL	
2 ea. GS-9 Data Collection Technician, 57 K ea.	114 K
3. Vision MFL	
2 ea. GS-9 Data Collection Technician, 57 K ea.	114 K
4. Cardiopulmonary MFL	
3 ea. GS-9 Data Collection Technician, 57 K ea.	171 K
1 ea. GS-12 Medical Officer	75 K
1 ea. GS-11 Physiologist	59 K
5. Field Support Staff	
1 ea. GS-11 Field Manager	59 K
1 ea. GS-11 Electronic Technician	59 K
STAFF PER DIEM COSTS:	
1. 13 Staff Members, 120 days, $85 day average	133 K
2. 3 ea. Rental Cars, 120 days, $36 day average	13 K
SITE SUPPORT/MAINTENANCE/UTILITIES	
1. 1 k per MFL per Month	16 K
MISCELLANEOUS COSTS	
1. Self-propelled MFL, Maintenance Shop,1 K per month	4 K
2. MFL Transportation, 4 K per MFL per trip	64 K
3. Biomedical Equipment Maintenance Contracts	100 K
TOTAL ESTIMATED COST	$ 1095 K

civilian billets will be provided to staff and operate the MFL units. If it is decided to utilize an outside contractor to furnish the manpower services, it is probable that the personnel costs will at least equal the Table I projections. In essence, adequate funding and staffing must be provided to fully support the NMRDC work units that will utilize the MFL units to meet project objectives.

REFERENCES

1. Cox, J. R., Benson, R. W. and Niemoeller, A. F., A Mobile Laboratory for Group Hearing Tests, Report No. 3, Project NM 001 102 502, U.S. Naval School of Aviation Medicine, Pensacola, FL, 30 November 1956. (AD 468 342)

2. Morris, A. and Goodson, J. E., "A Description of the Naval Aerospace Medical Research Vision Test Battery." Preprints of the Aerospace Medical Association 1983 Annual Scientific Meeting, pp. 40-41, 1983.

Other Related NAMRL Publications

None are applicable.

TMENT OF THE NAVY

MMANDING OFFICER
AEROSPACE MEDICAL
EARCH LABORATORY
AVAL AIR STATION
ACOLA, FL 32508-5700